Dec. 5, 1933. A. C. NORTON 1,937,663

METHOD OF MAKING SHEET METAL FLUME TROUGHS

Filed April 30, 1932 2 Sheets-Sheet 1

Fig. 1.

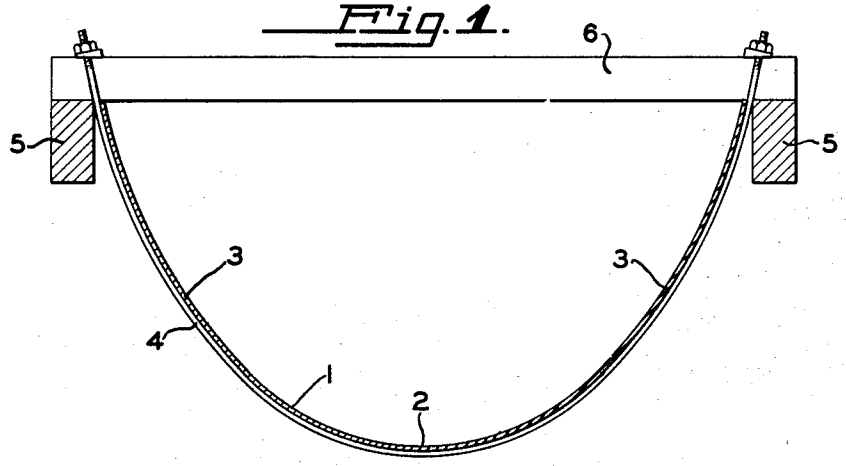
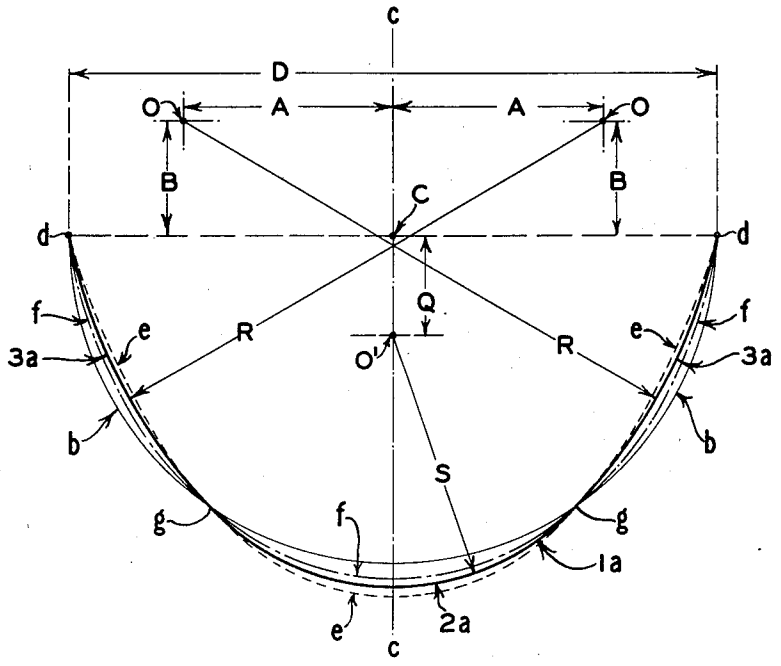


Fig. 2.



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Filed April 30, 1932 2 Sheets-Sheet 2

Fig. 3.

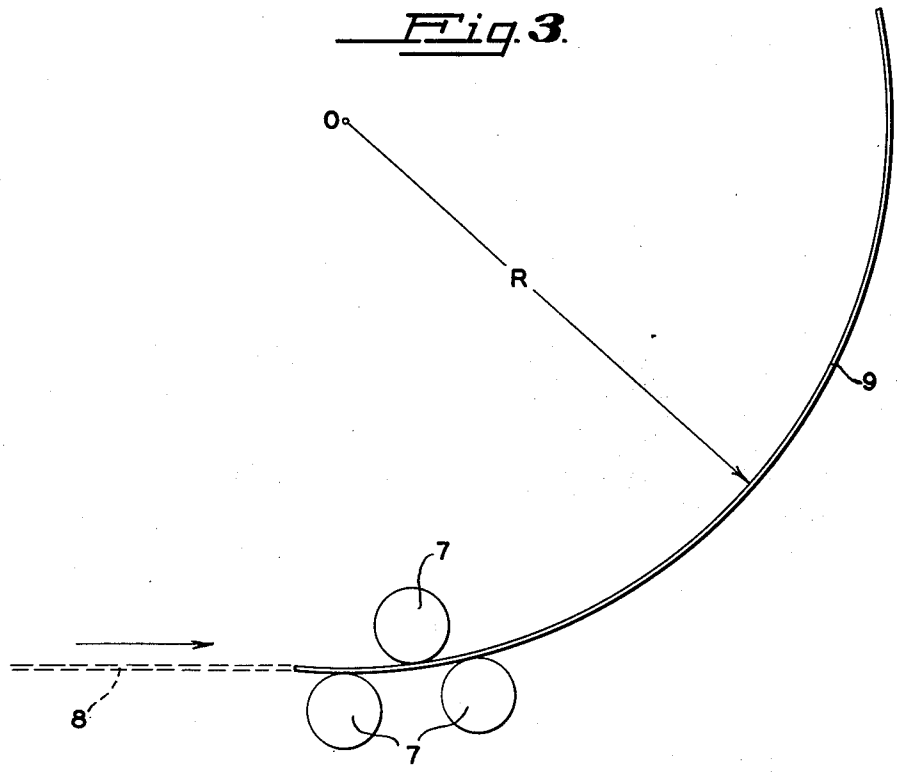
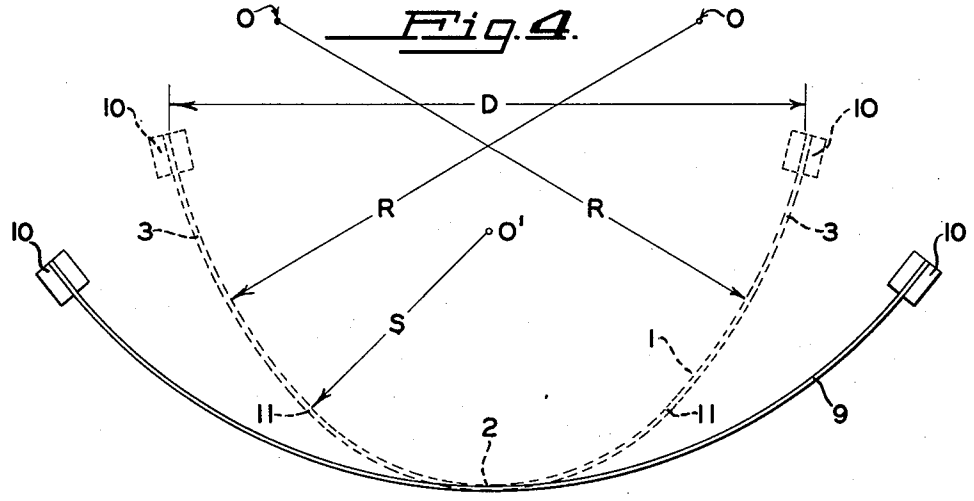


Fig. 4.



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METHOD OF MAKING SHEET METAL FLUME TROUGHS

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Application April 30, 1932. Serial No. 608,396

5 Claims. (Cl. 153—32)

The present invention relates to the manufacture of sheet metal troughs used in flumes for the transportation of water.

Sheet metal flume troughs are commonly formed initially to semicircular cross section. It is well known in the art, however, that such cross section is distorted under load, and tends to assume a curvature corresponding approximately to the hydraulic catenary. Such distortion is resisted to some extent by the stiffness of the sheet metal, and still more by the suspending rods and the transverse joints between adjacent trough sections, said joints usually including both transverse beads formed in the metal of the trough section and transverse clamping rods. The curvature of the trough also changes with variations in load, the deflection from the semicircle being greatest when the trough is about half full of water, and decreasing as the load approaches the maximum.

Distortion of initially semicircular flumes has caused much annoyance and expense by producing leaks at the joints, especially at the ends of the flume, where the sheet-metal trough joins rigid structures such as concrete head walls. Attempts have been made to overcome this leakage by forming the concrete structure to a theoretical catenary curvature where it is in contact with the sheet metal trough. Such attempts have not been successful, because of the fact that the curvature assumed by the loaded trough is not a true catenary, and cannot be calculated by any mathematical formula heretofore known.

I have found it possible to overcome the difficulties inherent in the semicircular sheet metal flume, and to prevent leakage and loosening of the joints and suspension rods, by forming the trough initially to a curve which may be defined broadly as the mean between the limits of distortion caused by variations in load, and which can be laid out about three major centers whose positions may be expressed as functions of the width across the top of the trough. I have also developed a simple and inexpensive method of forming the sheet to the compound curve above described, all of which results in a flume superior to those now in use. The employment of a sheet metal trough of compound curvature also enables me to make important economies in the supporting substructure, as described and claimed in my United States Letters Patent 1,878,289 for Flumes.

My invention will now be described in detail with reference to the accompanying drawings, it being understood that changes may be made, within the limits of the claims hereto appended, without departing from the spirit of the invention as defined in said claims.

In the drawings:—

Fig. 1 is a transverse section of a trough formed according to my invention.

Fig. 2 is a diagram illustrating the layout of the compound curve upon which the trough is formed, and showing the deflection from the semicircle and the limits thereof under varying loads.

Figs. 3 and 4 are diagrammatic end elevations illustrating respectively the successive steps in my improved method of forming the trough to the compound curve shown in Fig. 2.

Referring more particularly to the drawings, the reference numeral 1 designates a trough formed from sheet metal with a rounded bottom 2 and divergent sides 3, the latter being curved inwardly upon a radius greater than that of said bottom. The trough is suspended by rods, one of which is shown at 4, extending transversely beneath it, the ends of said rods being secured to the frame or substructure, a conventional form of which is shown in Fig. 1 comprising longitudinal stringers 5 and cross bars 6. In my improved construction, the upper portions of the sides 3 of the trough diverge at angles of about 16 degrees from the vertical, and the upper end portions of the rods 4, where they are attached to the frame, are also positioned at the same angle.

My trough 1 is formed of any suitable metal, preferably galvanized sheet steel of the weight and stiffness ordinarily used in such structures. Its cross sectional shape is a compound curve drawn about three major centers, with narrow transition areas of changing radius connecting the major arcs. In the theoretical consideration of the curve, these transition areas may be ignored, however. The curve and its mathematical layout are illustrated diagrammatically in Fig. 2, in which the heavy solid line 1*a* is the curve upon which the trough 1 is formed, 2*a* being the central arc of shorter radius and 3*a* the side arcs of longer radius, corresponding respectively to the bottom 2 and sides 3 of the trough. The curve 1*a* is constructed as follows:

Upon a horizontal line *d*—*d*, whose length D is the desired width across the top of the trough, construct a semicircle with D as its diameter, as shown by the light solid line *b*. The length of said semicircle, i. e. one half the circumference of a circle whose diameter is D, or 1.5708 D, will be the width of the sheet from which the trough

is to be formed. Draw a vertical line *c*—*c* through the center C of the semicircle. Locate the points O on either side of the vertical center line *c*—*c* and above the horizontal line *d*—*d*, the horizontal distance A between said points O and the vertical center line being approximately equal to 0.317D, and their vertical distance B above the horizontal line being approximately equal to 0.173D. Using the points O as centers, and the greater distance O*d*, or R, as radius, draw arcs 3*a* downwardly from the line *d*—*d*. The distance O*d*, or R, is approximately equal to 0.834 D, and is the radius of curvature of the divergent sides 3 of the trough. Now locate O′ upon the vertical center line at a distance Q, approximately equal to 0.147D below the horizontal line. Then with O′ as a center and with radius S approximately equal to 0.384D, draw the arc 2*a* intersecting and joining the arcs 3*a*. The arc 2*a* corresponds to the bottom 2 of the trough. The result is the compound curve shown by the solid line 1*a*. It is not a true catenary, because it is drawn about three fixed centers.

The curve above described was originally determined empirically. A semicircular sheet metal trough of standard weight was loaded until it showed, by actual measurement, its maximum deflection. This maximum deflection, indicated in Fig. 2 by the broken line *e*, occurred when the trough was between one-third and one-half full of water. As the load was increased, the deflection decreased, until, when the trough was loaded to maximum capacity, the measured deflection was as shown by the broken line *f*. Upon reducing the load, the measured deflection first increased to the broken line *e*, and then subsequently decreased, but never fell below the broken line *f* even when the trough was empty, the metal having received a permanent set which prevented it from returning closer to semicircular form than the maximum load curve *f*. The curves *e* and *f* therefore represent the limits of deflection or distortion to which the trough is subjected under all conditions of varying load. When these limits were determined and plotted as the curves *e* and *f*, a curve representing a mean was drawn between them, and this mean (the curve 1*a*) was found to be formed almost exactly about the three centers O and O′, whose positions, as well as the radii R and S of the compound curve, could be expressed in terms of the diameter D.

It will be apparent that, by initially forming my trough to the compound curve described above, I have not only eliminated entirely the major distortion from semicircular form which occurs upon the initial loading of the flume, but I have also reduced by fifty per cent the effects of the subsequent distortion due to variations in load. My flume, having an initial and natural (i. e. when not under stress) curvature corresponding to the mean of the maximum and minimum load distortion, is only deflected by an amount equal to one half the maximum in either direction, which is a negligible factor in causing leaks and deterioration. Moreover, there is no appreciable variation with changes in load in the inclination of the upper portions of the trough sides 3 and suspension rods 4, so that bending of said rods, at their points of attachment to the frame, is reduced to a negligible quantity.

My improved method of forming the trough to the above described curvature consists in first rolling a flat sheet throughout its entire width to the curvature of the greater radius R, as illustrated in Fig. 3, wherein 7 indicates any suitable rolling instrumentality, 8 is the position and path of the incoming flat sheet, and 9 is the formed sheet curved throughout its width to the radius R. The edges of the arcuate sheet are then grasped by any suitable clamping means indicated at 10 in Fig. 4, and are forced toward each other until said edges are the desired distance D apart. The bottom of the trough will then have a curvature of radius S, assuming such curvature by natural bending resulting from forcing its edges together.

It will be seen that this process is extremely simple and inexpensive, involving as it does only one rolling operation upon an arc of constant radius, and one subsequent bending operation, both of which can be done with the simplest form of apparatus. Starting with the known width D across the top of the trough, a sheet is provided whose width is equal to the semicircle upon D as its diameter, or 1.5708D. Using the formula hereinbefore described, the bending rolls 7 are set to produce an arc having the radius R or 0.834D. Then the edges of the arcuate sheet are brought toward each other until they are separated by the distance D, whereupon the central portion of the sheet, forming the bottom of the trough, will automatically assume an arc of radius S. Therefore the only values which need be known, in the practical operation of forming the trough, are its width D, the width of the sheet, 1.5708D, and the radius R, 0.834D.

The above described method of forming the trough will provide small transition areas 11 between the sides and bottom where the radius changes from R to S; that is to say, the radius of the formed trough does not change abruptly from R to S, as in the mathematical layout shown in Fig. 2. These transition areas are so narrow, however, as to be negligible for all practical purposes, and as they occur at the points *g* of Fig. 2, where the curves of maximum and minimum deflection *e* and *f* cross, they have no effect upon the value of the curve 1*a* as a mean between said maximum and minimum.

Obviously, the sides 3 of the trough may be extended upwardly to provide a free-board above the maximum water line, to prevent spilling at curves in the flume or as a result of waves, and such free-board portions of the sides may be either straight and curved, as desired, since they are not affected by the loading of the flume. When such free-boards are provided, either straight or curved upon a radius other than R, the basic width D is the width across the flume at the maximum water level, and the width of the sheet must be increased by the sum of the widths of the free-board portions. That portion of the sheet below the maximum water level or width line D is treated exactly as hereinbefore described.

The numerical values stated herein for the radii R and S and the co-ordinates of the centers O and O′ are those which give best results under average conditions. Obviously, however, it may be desirable to vary said values slightly to suit particular conditions in some cases, and such variations are to be considered as indicated within the spirit of the invention and its definition as set forth in the following claims.

I claim:

1. The method of forming a sheet metal trough to compound cross sectional curvature which consists in first bending a sheet laterally to a curvature of constant radius, the width of the sheet being equal to one half the circumference of a circle whose diameter is the desired width

across the top of the finished trough, and said radius being equal to 0.834 times said diameter; and then further bending the central portion of the sheet to a radius equal to 0.384 times said diameter.

2. The method of forming a sheet metal trough to compound cross sectional curvature which consists in first bending a sheet laterally to a curvature of constant radius, the width of the sheet being equal to one half the circumference of a circle whose diameter is the desired width across the top of the finished trough, and said radius being greater than the radius of said circle; and then further bending the central portion of the sheet to a curvature whose radius is less than the radius of said circle.

3. The method of forming a sheet metal trough to compound cross sectional curvature which consists in first bending a sheet laterally to a curvature of constant radius, said radius being equal to 0.834 times the desired width across the finished trough at its maximum water level, and then further bending the central region of said sheet to a curvature whose radius is 0.384 times said width.

4. The method of forming a sheet metal trough to compound cross sectional curvature which consists in first bending a sheet to a curvature of constant radius, said radius being greater than one half of the desired width of the finished trough, and then further bending the central portion of the sheet to a curvature whose radius is less than one half of said desired width, the side portions of the trough remaining at substantially the first mentioned curvature.

5. The method of forming a sheet metal trough to compound cross sectional curvature which consists in first bending a sheet to a curvature of constant radius, said radius being greater than one half of the desired width of the finished trough, and then applying pressure directly to the edge portions of said sheet to force them together to said desired width, thereby further bending the central portion of the sheet to a curvature whose radius is less than said desired width.

ALBERT COLWELL NORTON.